PHYSIOGRAPHIC NOTES FROM THE UNIVERSITY OF WESTERN AUSTRALIA.

THE PHYSIOGRAPHIC ELEMENTS OF THE SWAN COASTAL PLAIN.

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The city of Perth stands upon the banks of the Swan River, here a mature stream flowing across a sandy plain some twenty miles in width. This plain has been described as the Swan Coastal Plain by Jutson in his comprehensive account of the Physiography of the State.*

The author desires to point out some details in connection with the structure to which attention was not drawn by Jutson in his more general account. On the east the plain is bounded by the scarp forming the western boundary of the Darling Peneplain.†

Between the laterite-capped summit of the Darling Peneplain and the reefs of Rottnest Island, Garden Island, etc, the author believes that at least a dozen distinct physiographic elements may be recognised. (See Fig. 1.)

(*a.*) The summit level of the Darling Peneplain.

This rises to a remarkably uniform level of about 800 feet above sea level and extends almost without variation in character for at least 200 miles in a north and south direction. It is capped by laterite and is intersected by deep youthful river valleys, carved out of it since its upheaval.

(*b.*) The edge of the Darling Peneplain is formed by a sharp escarpement, the "Darling Scarp," due, proximately, to the undermining of the hard laterite capping by the forces of erosion. While, as Jutson has pointed out, this feature is a fault scarp, the present edge of the plateau is not coincident with the actual fault plane, but has retreated some distance to the east of the earth-crack as a result of erosion.

(*c.*) West of the cliff-like edge of the laterite capping is a hill slope, generally fairly steep, leading down to the edge of the plain itself. This element we may call "the Foothill Zone." On these foothills are exposed the basement rocks of the Peneplain, chiefly granites in great variety, seamed with dyke-like masses of basic and ultrabasic intrusive rocks, mostly somewhat recrystallised. From

*Jutson, J. T. : An outline of the physiographical geology (Physiography) of Western Australia. Geol. Survey of W.A., Bulletin 61, p. 44, 1914.

†Loc. cit., p. 42, 43, where references to previous literature are given.

Gosnells to Mundijong, at least, there appear at intervals exposures of slaty rocks, dipping at high angles, and apparently surrounded completely by eruptive materials.* In places, also, enormous quartz reefs, or sections of one great quartz reef, are met with (Brunswick, Gosnells, etc.).

This exposure of relatively fresh and undecomposed basement rocks bespeaks the rapid erosion which is going on throughout the foothill zone.

(*d.*) At several points along the outer part of the foothill zone there appears a laterite-covered shelf at a very strikingly uniform elevation of about 200 feet above sea level. It appears, rather obscurely, at Greenmount and Armadale, much more decidedly at Ridge Hill, the lower part of the Kalamunda Road, and Waroona. The appearance of this laterite at all points, and its relationships at Ridge Hill and Kalamunda, seem to distinguish it from the widely-distributed detrital laterite described by Simpson† as occurring at low levels. Much more research will have to be carried out before the existence of this shelf as a definite independent element can be claimed. Tentatively, however, we may suggest its existence and explain it as the remnants of a step-faulted portion of the plateau, let down by a subsidiary fault, immediately to the west of, and parallel to the main Darling Range fault.

For this somewhat hypothetical element I suggest the name "Ridge Hill Shelf."

(*e.*) We reach now the main "Darling Fault" which has been responsible for the entire structure of the region, and which separates the isostatically adjusted uplift area on the east, and subsidence area on the west. The actual fault plain is not known to the author at any point, the line of junction of the ancient crystalline rocks of the plateau and of the recent accumulations of the plain being hidden by detritus. Of the existence of such a fault, however, there can be no doubt, and of its tectonic importance there can be no question.

(*f.*) The "Piedmont Zone" follows next in order and is of the utmost economic importance. Steep-grade, rapid streams flowing down from the youthful valleys of the plateau element bear with them the well rotted detritus derived from both granites and "greenstones." On reaching the plains these streams have their velocity checked and are forced to deposit their sediment as flat alluvial fans or dry deltas. The streams are legion, and deposits of adjacent streams uniting at their lateral edges, build up an almost continuous, gently sloping zone of alluvial matter right along the base of the main hill feature. Containing as it does a modicum of potash derived from the felspars of the granites, and quite a notable amount of lime ob-

* Honman, C. S., The Extension of the Kelmscott Clay Deposit. Bull. Geol. Survey W.A., No. 48, 1912, pp. 63-65.

†Simpson, E. S.: Laterite in Western Australia. Geol. Mag. n.s. dec. v. vol. ix., p. 399-406, 1912.

tained from the greenstone, the soils of this piedmont zone are, relatively, somewhat rich in plant food. The distribution of land suitable for citrus fruits, limited on the west by a line approximating to the South-Western railway is determined by the extent of this zone.

Each alluvial fan is slightly convex in profile and its stream occupies a notch on this convex surface. This introduces a tendency to instability of location of the channel, and there are probably instances of streams having left the convex surface to flow into the intervening hollows. Mostly, however, the streams occupy notches on the fans, a feature which is evidenced by the occurrence of the viaducts along the railway line at the summits of the grades in many instances. (A very good example of this is at Keysbrook.) The outer margin of the piedmont zone is lobate, and cusps of the plain run in between the lobes. The width of the belt varies considerably with the magnitude of the constructive streams, but is probably only from half to one mile on the average.

(*g.*) The "Sandy Plain" follows the piedmont zone on the west. Into its constitution a number of sub-elements enter, whose relations vary considerably from point to point. As a whole the sandy plain is gently undulating, but quite sharp gradients are by no means infrequent. These are caused by the dominating structures of the region, namely, sand dunes of æolian origin, geologically recent, but sufficiently old to have been fixed completely and permanently by the growth of vegetation. Between these dunes there stretch low lying areas. During the extremely wet winter season the level of ground water rises to the surface in such localities, and we have swampy areas filled with coffee-coloured peaty water. These swampy areas come to contain a moderate amount of clay substance and humus so that, when drained and cultivated, they become quite valuable agricultural land, particularly for market gardens. The Chinamen's gardens in the immediate vicinity of Perth are examples.

Quite distinct from these smaller sporadic lagoons, there is a well-defined zone of large and shallow, but more or less permanent, lakes stretching along a north and south line between the hills on the east and the coastline on the west, including, amongst others, Lakes Jandakot, Bibra, Herdsman, Monger, etc. The origin of these lakes is under investigation and will form the subject of a further communication to the Society. Beyond the "Lake Zone" the sandhills of the plain continue to the west as they do to the east, but they become more pronounced and individualised, probably because more recent, in this western section.

(*h.*) Forming a continuous belt facing the coast, rising into very respectable hills (Buckland Hill 207 feet), and projecting seawards as rocky headlands honeycombed with large and small cavities, is the zone of "Coastal Limestones." Formed by æolian action on the existing coastline, and composed largely of comminuted mar-

ine calcareous organisms, these rocks have been consolidated superficially into dense travertine ("cap-stone") in many places by alternate solution and precipitation of carbonate of lime. As a result of this mode of origin concretionary structure is very wide spread. Travertine formation has been very irregular, or else solution channels have been frequent, or both factors in development have been operative. As a result extraordinary "nigger-heads" and "teeth" of limestone have been formed or left amongst the less solid sand. These are well exhibited in the railway cuttings near the Show Ground and in the river bank near the boat-sheds at Peppermint Grove.

Plant roots have formed channels for percolating water and may, perhaps, have contributed organic solvents during life or during decay, so that the segregation of calcium carbonate has been directed, in its first stages at all events, by root distribution. The structure lines so initiated have been extended and enlarged, producing the arborescent rods of limestone which form so striking a feature of the railway cuttings between Cottesloe Beach and North Fremantle.

False bedding has been extensively developed during the formation of these rocks and gives rise to very striking features in the topography produced by them (for example, near the Mount Lyell Chemical Works at Rocky Bay).

In places (*e.g.*, North Fremantle) the superficial crust of limestone is sufficiently pure to be burnt for lime, while at various places in the Metropolitan area the subjacent calcareous sandstones have supplied rather inferior building stone and road metal.

(*k.*) Next in succession we come to the actual "Shore Line" of the Indian Ocean. This is composed mostly of sandy beaches backed by actively moving sand dunes, which, in places, are encroaching very seriously upon residential and industrial areas. Extensive rocky promontories are scarcely existent, but small headlands of coastal limestone alternate with the sand beaches. A well-defined wave-cut platform of limestone is recognisable in places at a level such that it is extensively exposed at low water. The significance of this platform is being discussed in another paper by Mr. J. L. Somerville.

(*l.*) In the immediate neighbourhood of Fremantle the shallow waters of "Gage Roads" enclosed between the shore and the Rottnest Island to Rockingham Bay reefs constitutes another physiographic element of no mean importance.

(*m.*) The zone of islands and reefs extending through Carnac and Garden Island and, perhaps, Rottnest Island, forms the most westerly of the physiographic elements included within the scope of the present paper. The author has not had an opportunity of examining them personally.

It is obvious, of course, that a method of subdivision like that attempted above is to some extent a matter of convenience. The various elements shade off into one another in many instances so

that no sharp line of demarcation can be drawn. In other cases portions of the different elements overlap and become intermingled, so that, for instance, we not infrequently find the tops of sandhills cropping up through the red soils of the piedmont zone.

The deposits of the larger streams, essentially resembling those of the piedmont in composition, may extend completely across the sand plain and limestone belt to the sea, while the development of a considerable river valley introduces features which tend to mask those of the coastal plains. It is in areas between the larger streams that the consecutive elements of structure can be recognised most clearly. The best point of outlook known to the author is to be found on the crest of the hills east of Armadale. In this paper no attempt has been made to deal with the question of stream development in the area, nor to account for the well defined and extensive coastal lakes and estuaries which present so striking a feature of the topography from Bunbury to Mandurah. These have been reserved for future study and communication to the Society. No bibliography has been included and few references have been given, as Jutson (*loc. cit.*) has provided all that is necessary in this particular.

GENERALISED SECTION ACROSS THE SWAN COASTAL PLAIN.

a. Summit level of Darling Peneplain (laterite-capped).

b. Darling scarp.

c. Foothill zone.

d. Ridge hill shelf (laterite-capped).

e. Main Darling fault.

f. Piedmont zone with relatively rich soil.

g. Sandy plain with sand hills (some of them limestone capped), lagoons, and lakes.

h. Coastal limestones.

k. Shore line.

l. Shallow roadstead.

m. Garden Island reef.